FIG. 1

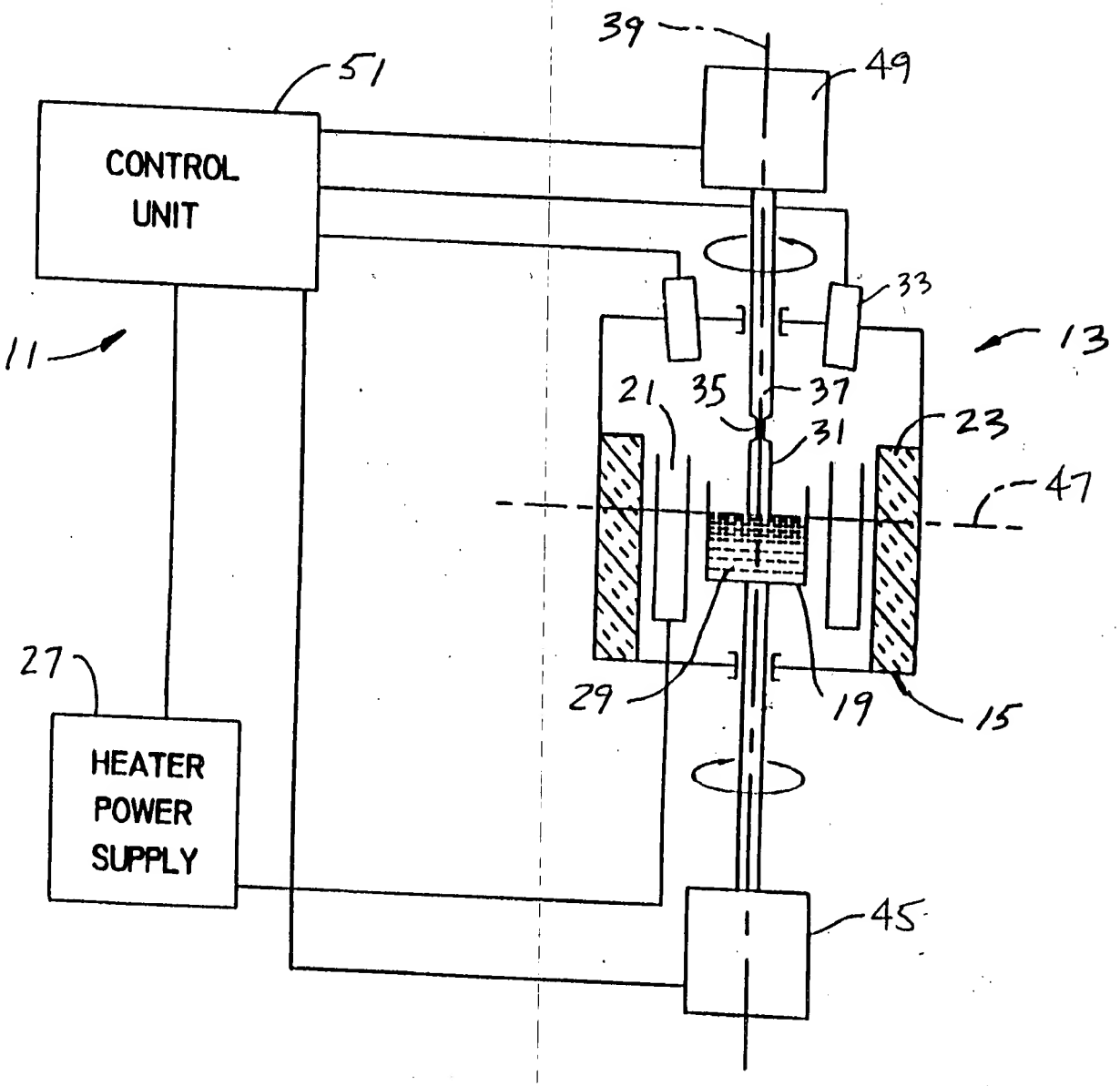

39
49
51
CONTROL UNIT
33
11
13
21
35
37
31
23
47
27
29
19
15
HEATER POWER SUPPLY
45

FIG. 2

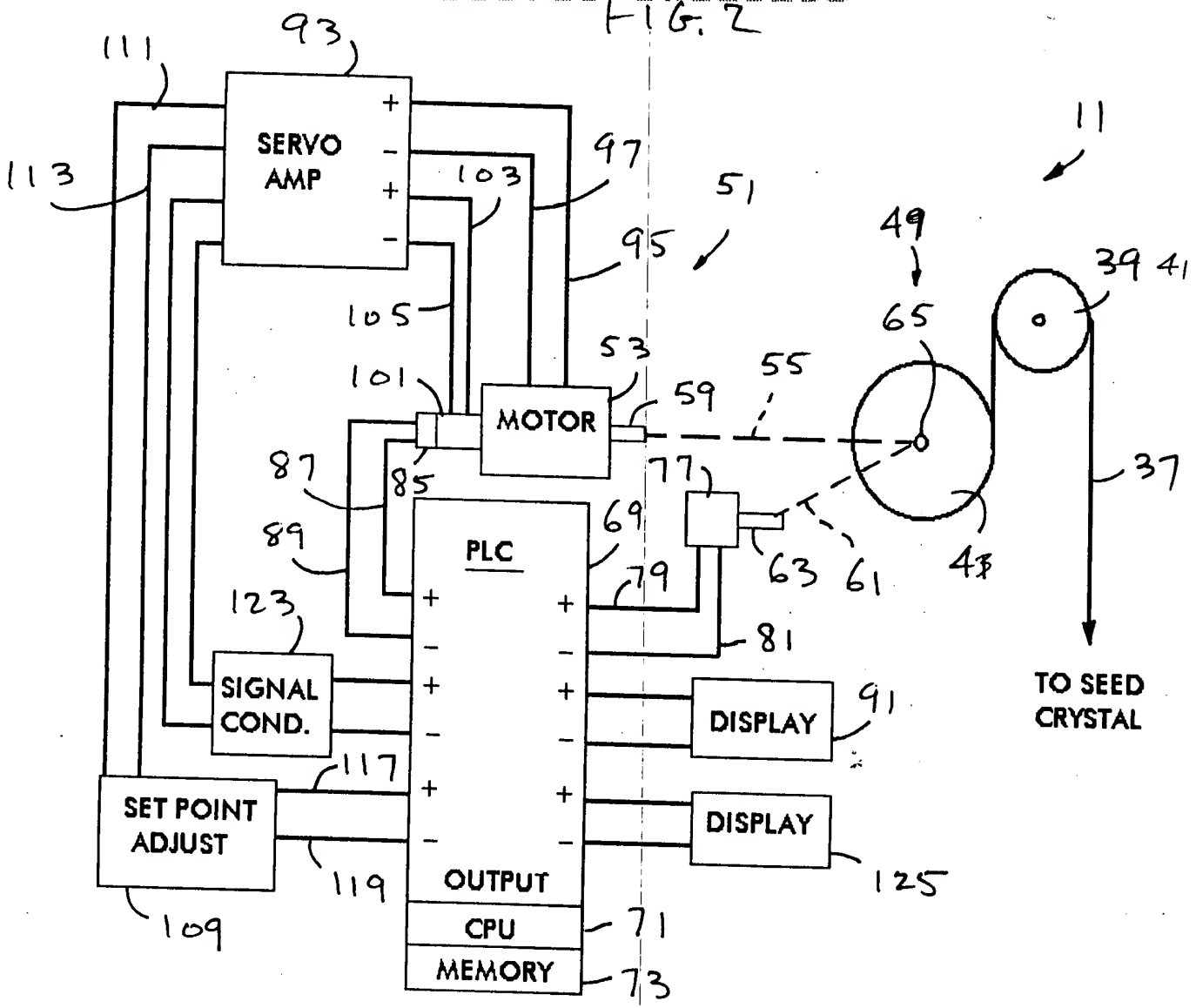
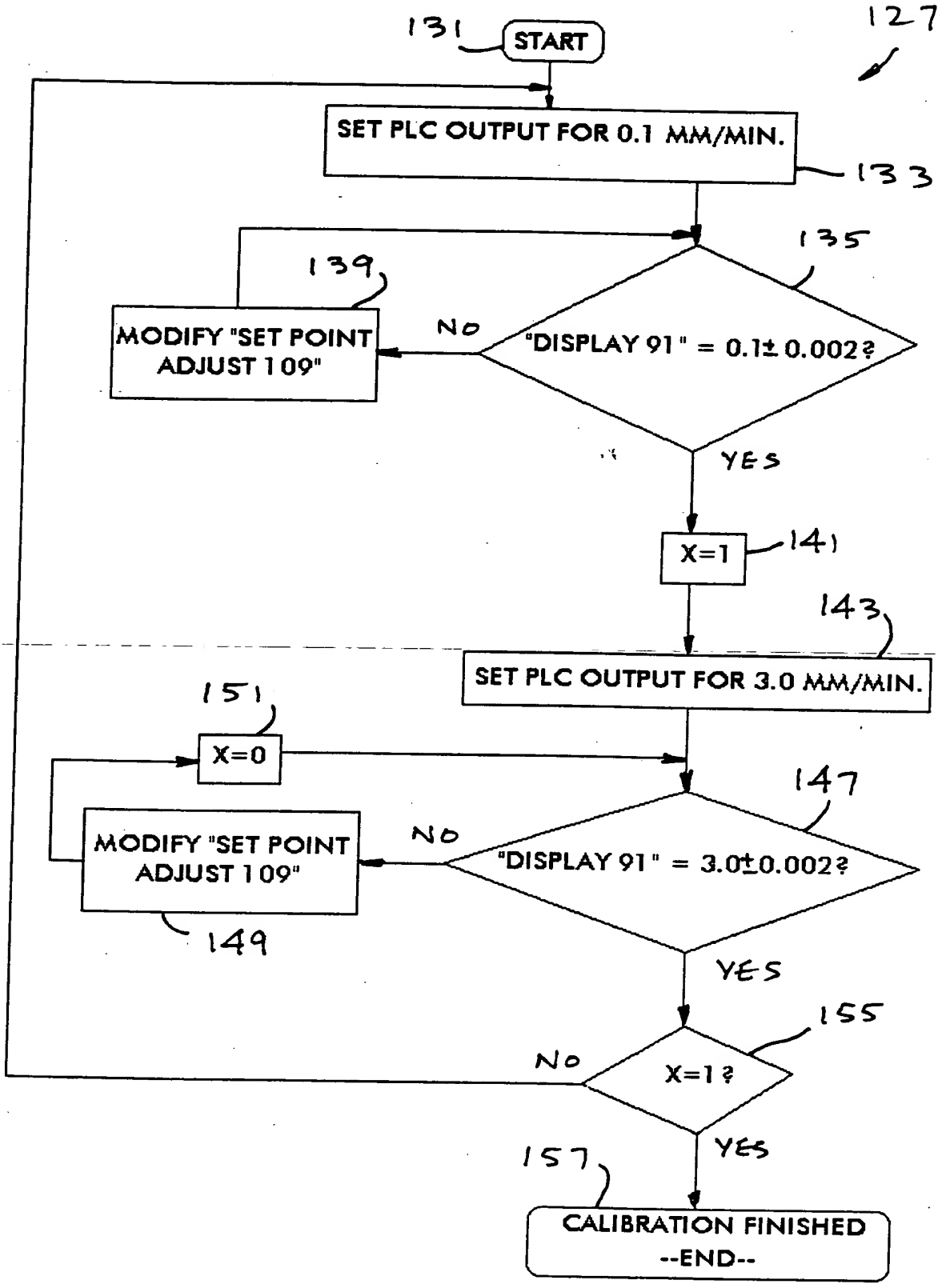

SERVO AMP
MOTOR
PLC
OUTPUT
CPU
MEMORY
SIGNAL COND.
SET POINT ADJUST
DISPLAY
DISPLAY
TO SEED CRYSTAL
11
93
111
113
97
103
95
51
49
65
39
41
105
101
53
55
59
87
85
77
69
89
79
63
61
48
37
123
81
91
117
119
109
125
71
73

FIG. 3


127
131
START
SET PLC OUTPUT FOR 0.1 MM/MIN.
133
135
"DISPLAY 91" = 0.1±0.002?
NO
139
MODIFY "SET POINT ADJUST 109"
YES
X=1
141
143
SET PLC OUTPUT FOR 3.0 MM/MIN.
151
X=0
147
"DISPLAY 91" = 3.0±0.002?
NO
MODIFY "SET POINT ADJUST 109"
149
YES
155
X=1?
NO
YES
157
CALIBRATION FINISHED
--END--

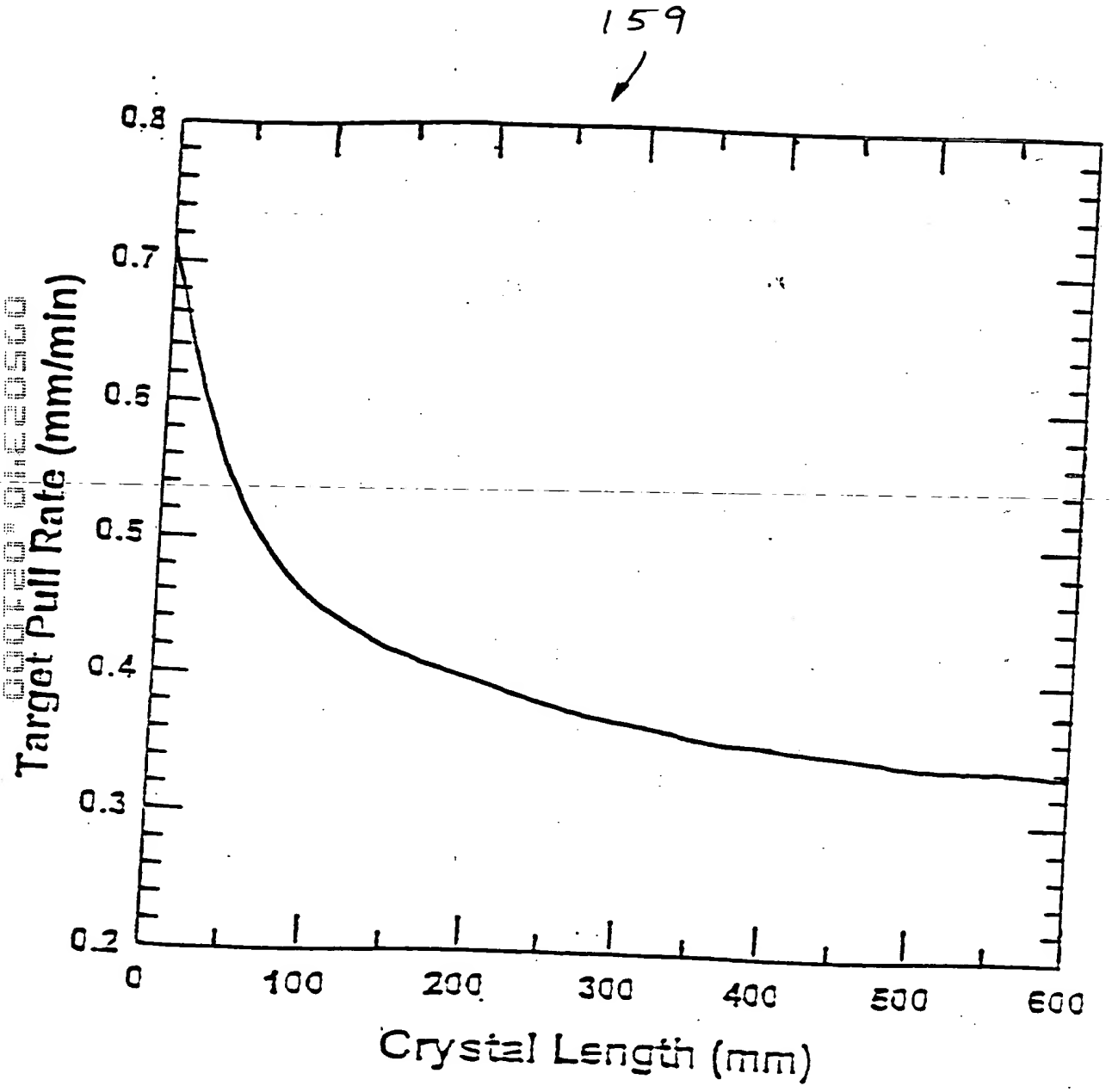

159
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Target Pull Rate (mm/min)
0
100
200
300
400
500
600
Crystal Length (mm)

FIG. 4

FIG. 5

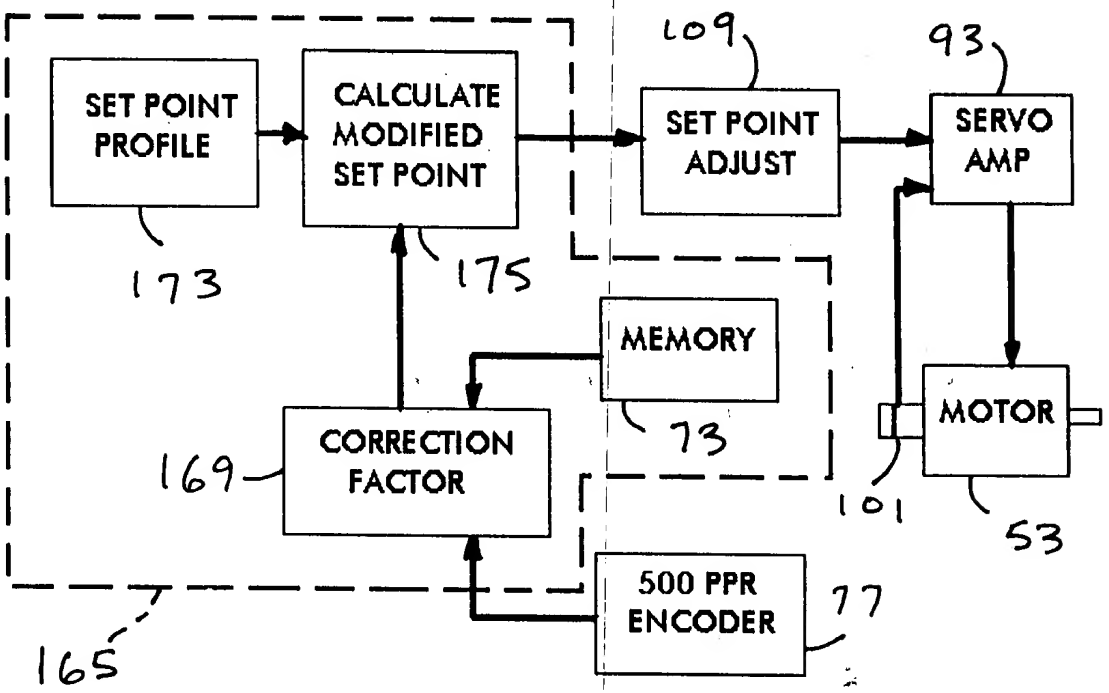

SET POINT PROFILE
CALCULATE MODIFIED SET POINT
SET POINT ADJUST
SERVO AMP
MEMORY
CORRECTION FACTOR
MOTOR
500 PPR ENCODER
173
175
109
93
73
169
101
53
77
165

FIG. 6A

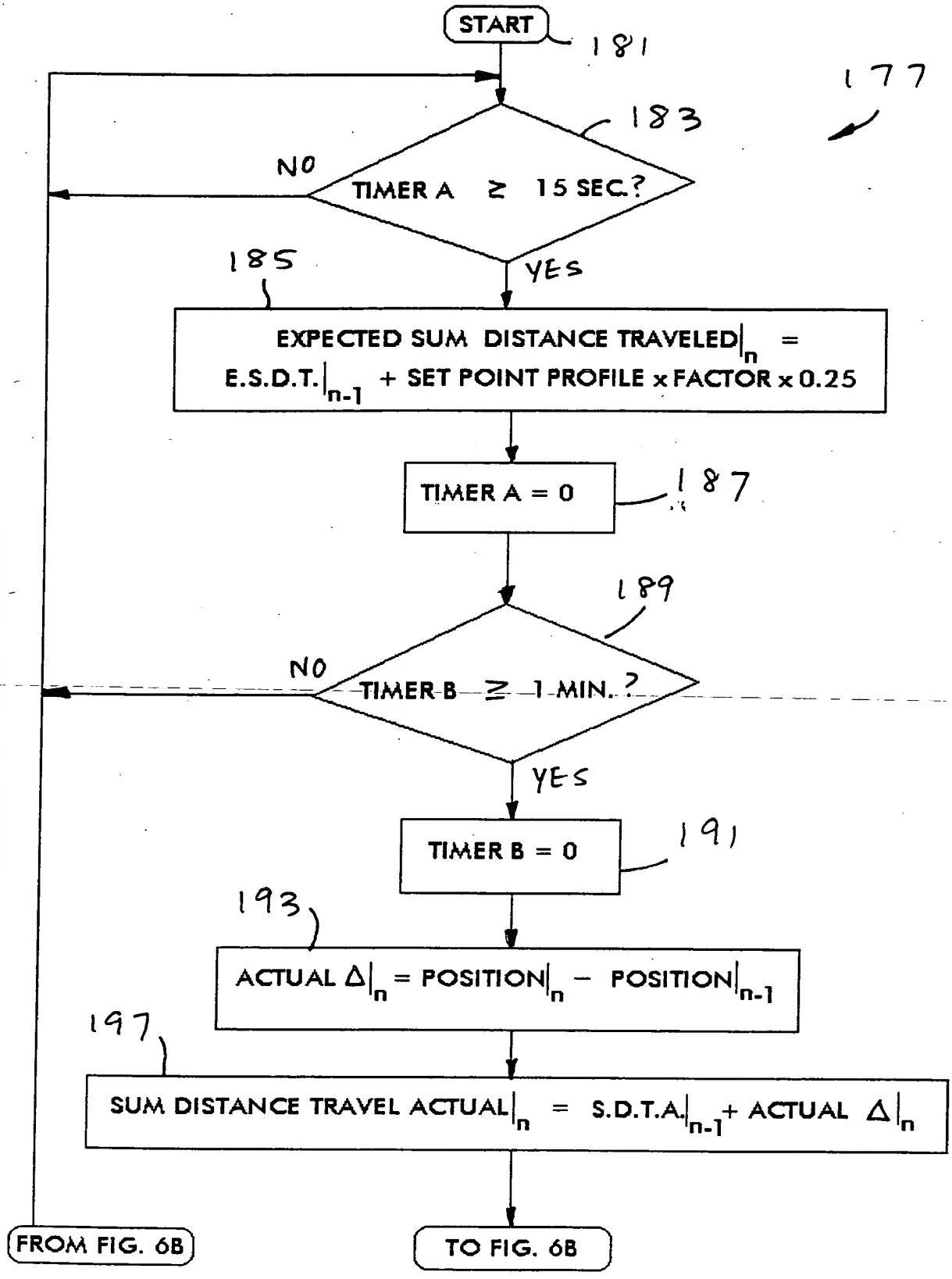
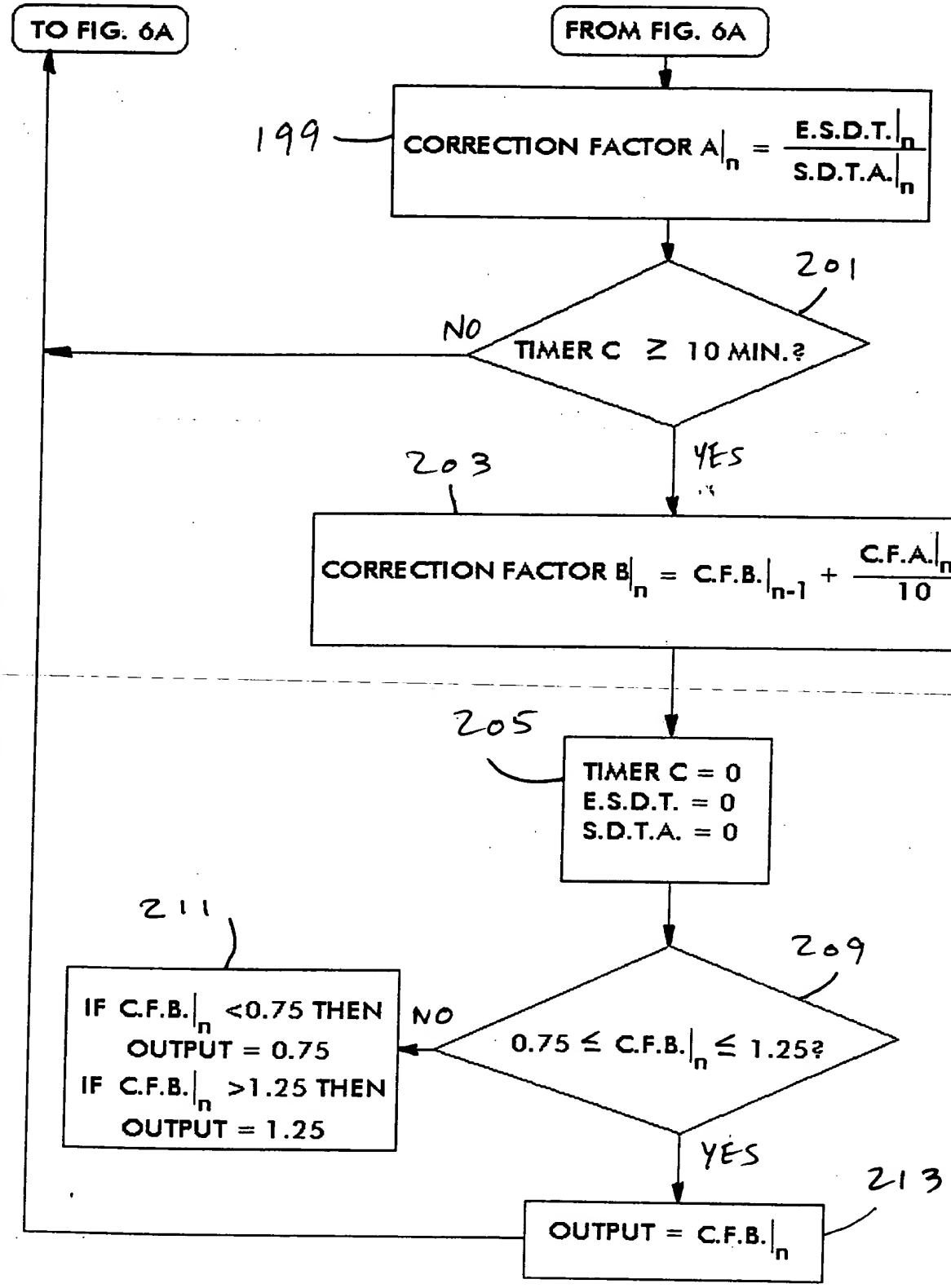

START
181
177
183
NO
TIMER A ≥ 15 SEC.?
YES
185
EXPECTED SUM DISTANCE TRAVELED|n =
E.S.D.T.|n-1 + SET POINT PROFILE x FACTOR x 0.25
TIMER A = 0
187
189
NO
TIMER B ≥ 1 MIN.?
YES
TIMER B = 0
191
193
ACTUAL Δ|n = POSITION|n − POSITION|n-1
197
SUM DISTANCE TRAVEL ACTUAL|n = S.D.T.A.|n-1 + ACTUAL Δ|n
FROM FIG. 6B
TO FIG. 6B

FIG. 6B


TO FIG. 6A
FROM FIG. 6A
199
CORRECTION FACTOR A|n = E.S.D.T.|n / S.D.T.A.|n
201
NO
TIMER C ≥ 10 MIN.?
YES
203
CORRECTION FACTOR B|n = C.F.B.|n-1 + (C.F.A.|n - 1) / 10
205
TIMER C = 0
E.S.D.T. = 0
S.D.T.A. = 0
211
IF C.F.B.|n <0.75 THEN OUTPUT = 0.75
IF C.F.B.|n >1.25 THEN OUTPUT = 1.25
209
NO
0.75 ≤ C.F.B.|n ≤ 1.25?
YES
213
OUTPUT = C.F.B.|n

000720" 01.E20560

Diameter Control Loop -- Seed Lift

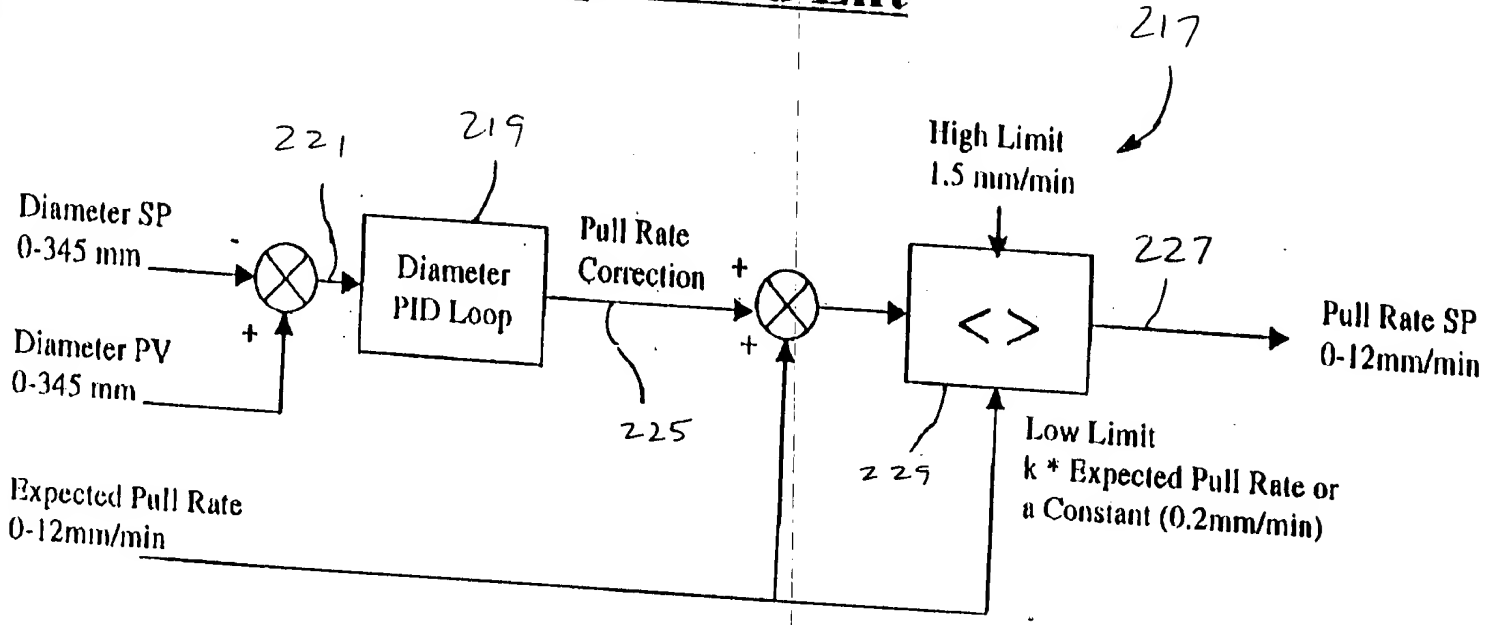


FIG. 7

PRIOR ART

FIG. 8 PRIOR ART

Cascaded Temperature Control Loops

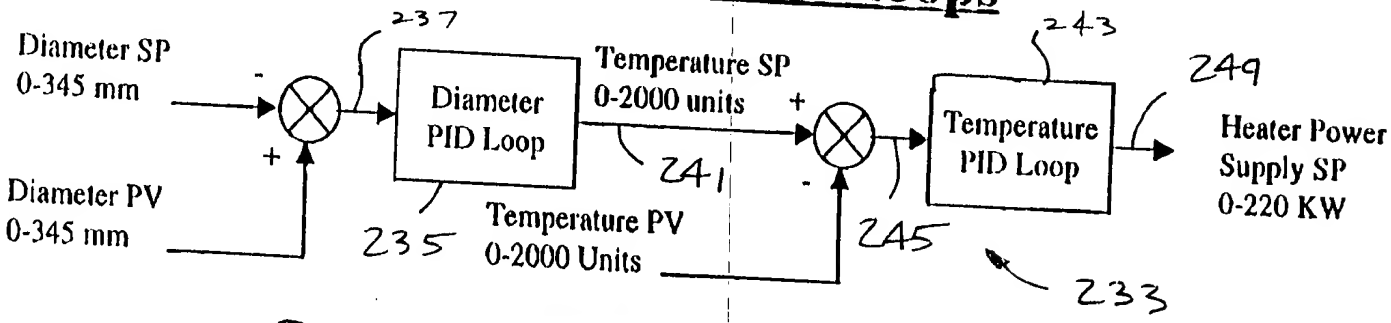


FIG. 9 PRIOR ART

Power Control Loop

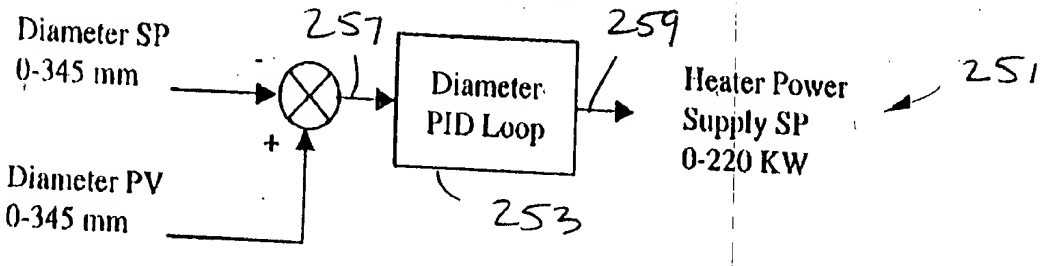


FIG. 10

Power Control Loop With Process Model

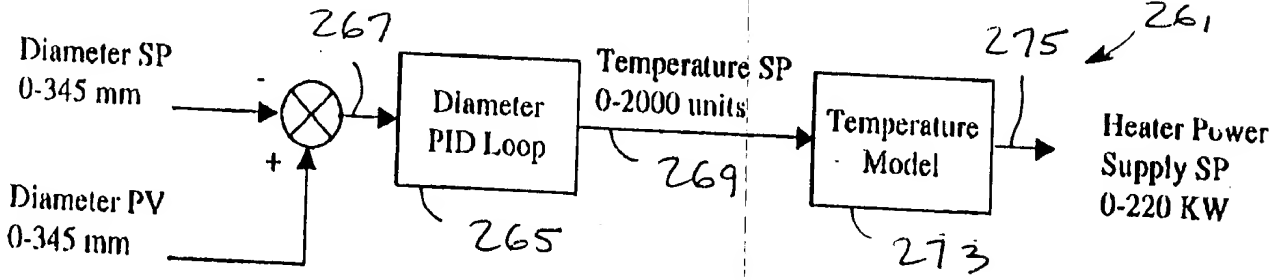
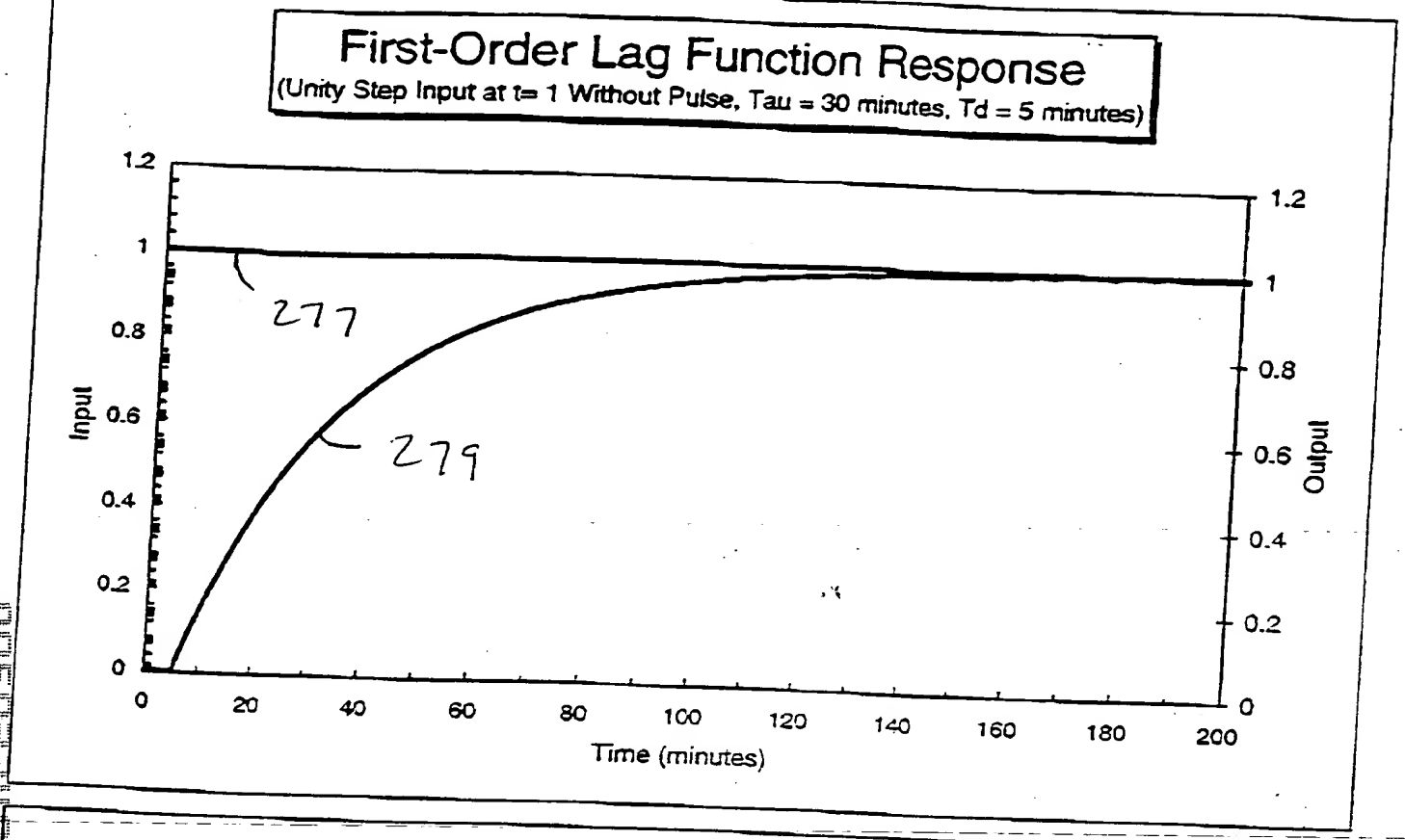


FIG. 11 PRIOR ART



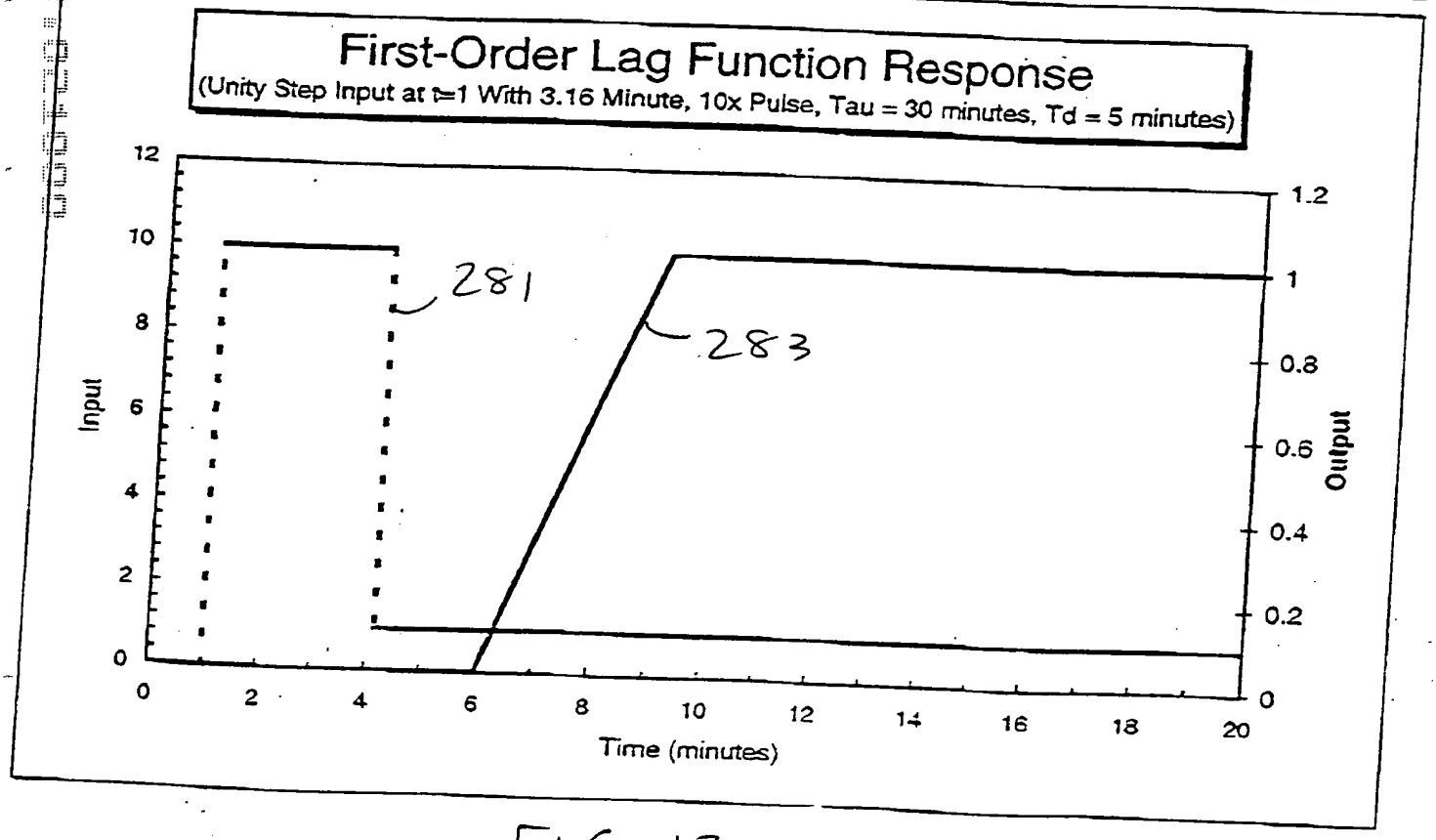
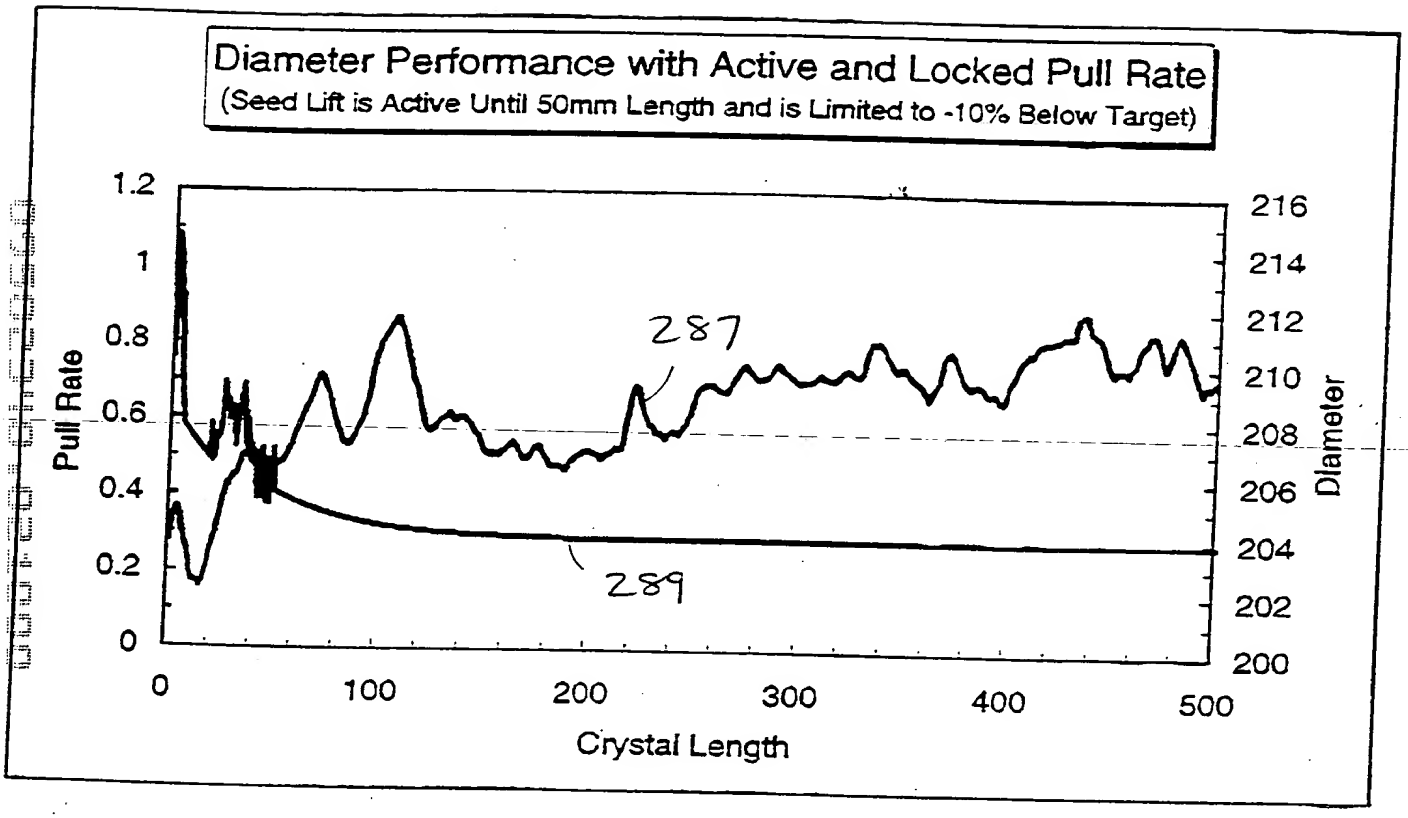


FIG. 12

FIG. 13


Diameter Performance with Active and Locked Pull Rate
(Seed Lift is Active Until 50mm Length and is Limited to -10% Below Target)
Pull Rate
1.2
1
0.8
0.6
0.4
0.2
0
Diameter
216
214
212
210
208
206
204
202
200
0
100
200
300
400
500
Crystal Length
287
289